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LISTS OF SPECIES

Check List 13(2): 2073, 28 March 2017 doi: https://doi.org/10.15560/13.2.2073
ISSN 1809-127X © 2017 Check List and Authors

Diversity of butterflies in an arboretum of Vadodara, Gujarat, India

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Abstract: Potent pollinators and ecological indicators, butterflies are important for estimating the general health of an ecosystem. Owing to the rich plant diversity (927 species), an arboretum in Vadodara, state of Gujarat, India was selected for surveying butterfly diversity. Our survey was conducted in all seasons for an entire year from October 2012 to October 2013 and revealed 61 species. Recorded were six species of Papilionidae, three species of Hesperiidae, 20 species of Nymphalidae, 13 species of Pieridae, and 19 species of Lycaenidae. *Junonia* dominated with five species, followed by *Eurema* (three species), *Graphium* (three species), and *Chilades* (three species). Our study gives a comprehensive insight into the species diversity and richness of butterflies in Vadodara and highlights the need to conserve rare and threatened butterfly species there.

Key words: Biodiversity; Lepidoptera; Wildlife Protection Act

INTRODUCTION

Biodiversity is important for estimating the general health as well as development of proper conservation plans for the entire ecosystem, especially in ecologically sensitive groups such as butterflies (Lepidoptera: Rhopalocera) (Chowdhury & Soren 2011). Butterflies are one of the best taxonomically studied groups of insects (Robbins & Opler 1997). New et al. (1995) called them the flagship taxa for invertebrate conservation, and the plight of butterflies has been a focus of entomologists for over a century. Lepidoptera are beneficial as pollinators, silk producers, indicators of environmental quality, and appreciated for their aesthetic value (Pollard 1991; Kunte 2000; Kumar 2012). The holometabolous life history of butterflies causes them to be exposed to a wide range of environmental influences, and they are highly sensitive to changes in temperature, humidity, and light levels (Erhardt 1985; Kremen 1992; Sparrow et al. 1994; Chey et al. 1997; Spitzer et al. 1997).

Increases in human population and advances in technology have directly affected the ecosystems of the world and many lepidopterans and other organisms cannot adapt these changes (Boonvanno et al. 2000; Brattstrom et al. 2008). Threats to the butterfly fauna include the use of pesticides, urbanization, intensive forestry, agriculture and exotic species (New 1997; Wagner & Van Driesche 2010). In addition, knowledge of butterfly diversity may aid as a substitute for plant diversity because butterflies are directly reliant on plants, often in highly co-evolved situations (Ehrlich & Raven 1964).

In this context, our study examines the diversity of butterflies in an arboretum and discusses the conservation needs of rare and threatened butterfly species. Studies in the past have been conducted on similar grounds in other nature parks and arboretums of the country (Raut and Pendharkar 2010; Patil & Shende 2014).

MATERIALS AND METHODS

Study site

The study area includes 4.85 ha arboretum in the city of Vadodara, Gujarat state, India (22°19′12.22″ N to 22° 19′19.95″ N and 073°10′47.40″ E to 073°10′42.85″ E). The arboretum situated on the distal part of human habitation within the urban expanse of the city (Figure 1). Based on the botanical survey of Daniel & Nagar (2010) this arboretum harbors 411 species of angiosperms, including 129 species of trees, 32 shrubs, 24 climbers and 80 herbs. It also has 148 plots of different medicinal plants (Daniel & Nagar 2010). Outside of the monsoon season that extends from mid-June to mid-September, the climate is dry. The average rainfall of the region is 93 cm whereas temperatures fall in the range of 12.5–40.1 °C (IMD 2014).

Field survey and data collection

Our survey was conducted in all seasons for an entire year from October 2012 to October 2013. Field observations were made on a daily basis between 10:00 to 17:00 h. Butterflies were recorded by visual observations, with the aid of binocular and a digital camera (Sony, HX100V). Butterflies

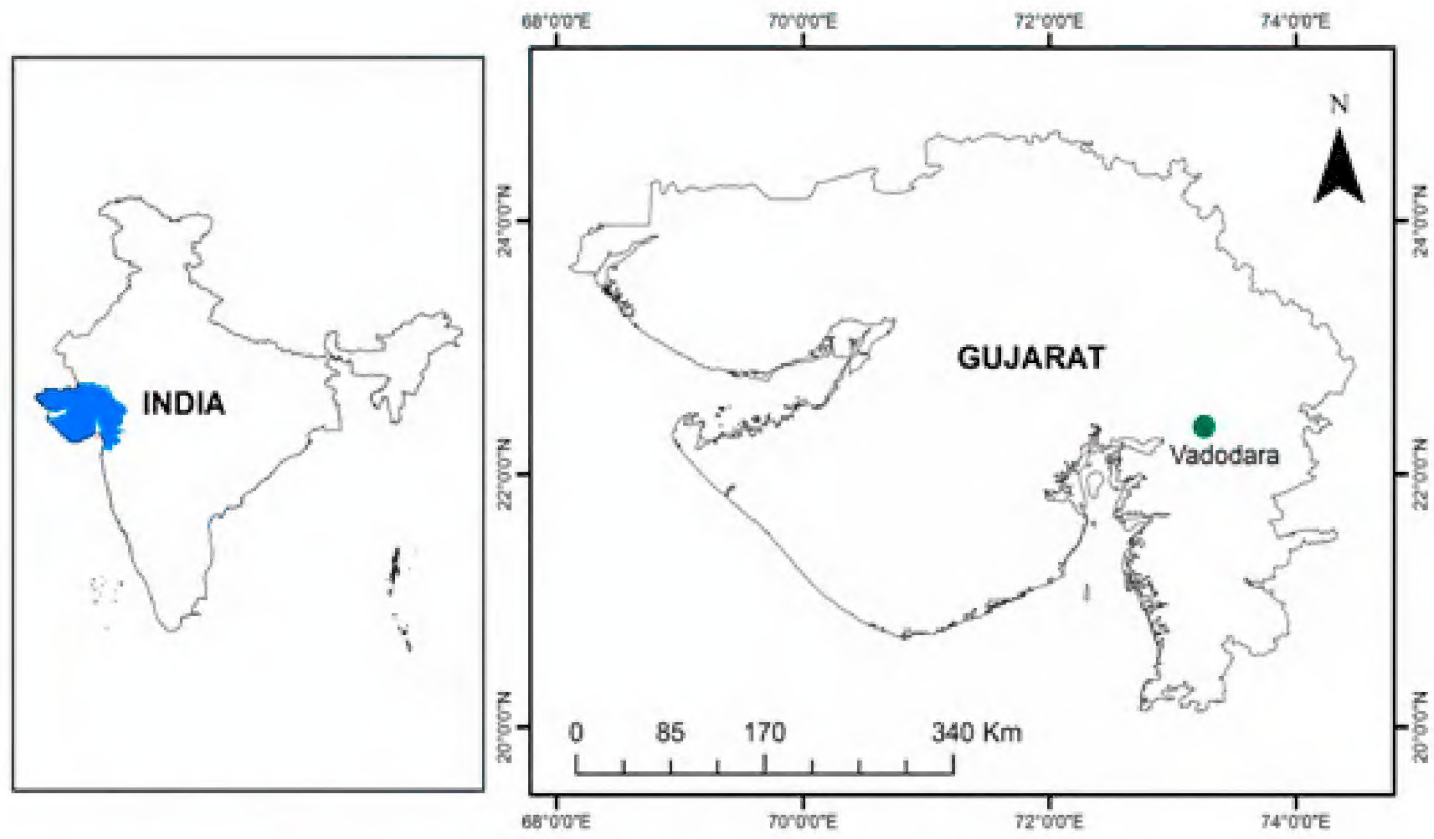


Figure 1. Location of the study site (arboretum) in Vadodara, state of Gujarat, India. (Source: Google Earth™).

were observed, photographed, and identified with the help of literature (Evans 1932; Wynter-Blyth 1957; Gay et al. 1992; Lewington 1999; Kunte 2000; Parasharya & Jani 2007; Kehimkar 2011). Some individuals of certain species were captured using a butterfly net, identified, and then released. Species richness was calculated as the total number of the species in a group in an area.

RESULTS

Species richness

We found 61 species belonging to 43 genera in five families (Figures 3–63; Table 1). The species richness was highest in Nymphalidae (20 species, 33% of the total) followed by Lycaenidae (19 species, 32%), Pieridae (13 species, 21%), Papilionidae (six species, 10%) and Hesperiidae (three species, 5%) (Figure 2). *Junonia* was the most species-rich genera, represented by five species.

Threatened taxa

Of the species recorded, nine species were listed under Schedule I of Part IV of the Indian Wildlife Protection Act, 1972 (Figures 55–63): *Castalius rosimon* (Fabricius, 1775), *Danaus chrysippus* (Linnaeus, 1758), *Danaus genutia* (Cramer, 1779), *Virachola isocrates* (Fabricius, 1793), *Hypolimnas bolina* (Linnaeus, 1758), *Hypolimnas misippus* (Linnaeus, 1764), *Jamides bochus* (Stoll, 1782), *Parantica aglea* (Stoll, 1782), and *Tirumala limniace* (Cramer, 1775).

Table 1. Butterfly diversity and its status in an arboretum, Vadodara, state of Gujarat, India.

Scientific name	Frequency encountered[#]
Papilionidae	
Graphium doson (Felder & Felder, 1864)	VC
Graphium agamemno (Linnaeus, 1758)	C
Graphium nomius (Esper, 1799)	VR
Pachliopta aristolochiae (Fabricius, 1775)	C
Papilio demoleus (Linnaeus, 1758)	C
Papilio polytes (Linnaeus, 1758)	UC
Hesperiidae	
Borbo cinnara (Wallace, 1866)	C
Pelopidas mathias (Fabricius, 1798)	C
Suastus gremius (Fabricius, 1798)	UC
Nymphalidae	
Danaus chrysippus (Linnaeus, 1758)*	VC
Danaus genutia (Cramer, 1779)*	UC
Tirumala limniace (Cramer, 1775)*	UC
Parantica aglea (Stoll, 1782)*	R
Euploea core (Cramer, 1780)	VC
Euploea klugii (Moore, 1857)	VR
Melanitis leda (Linnaeus, 1758)	VR
Phalanta phalantha (Drury, 1773)	UC
Acraea terpsicore (Linnaeus, 1758)	C
Ariadne merione (Cramer, 1777)	VC
Ariadne ariadne (Linnaeus,1763)	VR
Junonia iphita (Cramer, 1779)	C
Junonia orithya (Linnaeus, 1758)	C
Junonia atlites (Linnaeus, 1763)	VR
Junonia lemonias (Linnaeus, 1758)	VC
Junonia almana (Linnaeus, 1758)	UC
Hypolimnas misippus (Linnaeus, 1764)*	C
Hypolimnas bolina (Linnaeus, 1758)*	C
Ypthima huebneri (Kirby, 1871)	VR
Lethe verma (Kollar, 1844)	VR
Pieridae	
Catopsilia pomona (Fabricius, 1775)	VC
Catopsilia pyranthe (Linnaeus, 1758)	UC
Eurema hecabe (Linnaeus, 1758)	VC
Eurema brigitta (Stoll, 1780)	C
Eurema laeta (Boisduval, 1836)	UC
Delias eucharis (Drury, 1773)	C
Pareronia hippia (Fabricius, 1787)	R
Ixias pyrene (Linnaeus, 1764)	VC
Ixias marianne (Cramer, 1779)	VR
Colotis danae (Fabricius, 1775)	UC
Colotis amata (Fabricius,1775)	VR
Belenois aurota (Fabricius,1793)	VC
Cepora nerissa (Fabricius, 1775)	VC
Lycaenidae	
Curetis thetis (Drury, 1773)	R
Virachola isocrates (Fabricius, 1793)*	UC
Rapala iarbus (Fabricius, 1787)	R
Castalius rosimon (Fabricius, 1775)*	VC
Tarucus nara (Kollar, 1848)	VR
Euchrysops cnejus (Fabricius, 1798)	C
Catochrysops strabo (Fabricius, 1793)	VC
Zizeeria karsandra (Moore, 1865)	C
Zizina otis (Fabricius, 1787)	C
Zizula hylax (Fabricius, 1775)	C
Lampides boeticus (Linnaeus, 1767)	VC
Chilades parrhasius (Fabricius, 1793)	C
Chilades pandava (Horsfield, 1829)	R
Chilades lajus (Stoll, 1780)	UC
Jamides bochus (Stoll, 1782)*	VR
Freyeria putli (Kollar, 1844)	VR
Anthene lycaenina (Felder, 1868)	R
Prosotas dubiosa (Semper, 1879)	UC
Leptotes plinius (Fabricius, 1793)	VC

* Listed under Schedule 1 of Part IV of the *Wildlife Protection Act, 1972*

[#]VC (very common): >100 individuals, C (common): <100 and >50 individuals, UC (uncommon): <50 and >25 individuals, R (rare): >25 and <10 individuals, VR (very rare): <10 individuals.

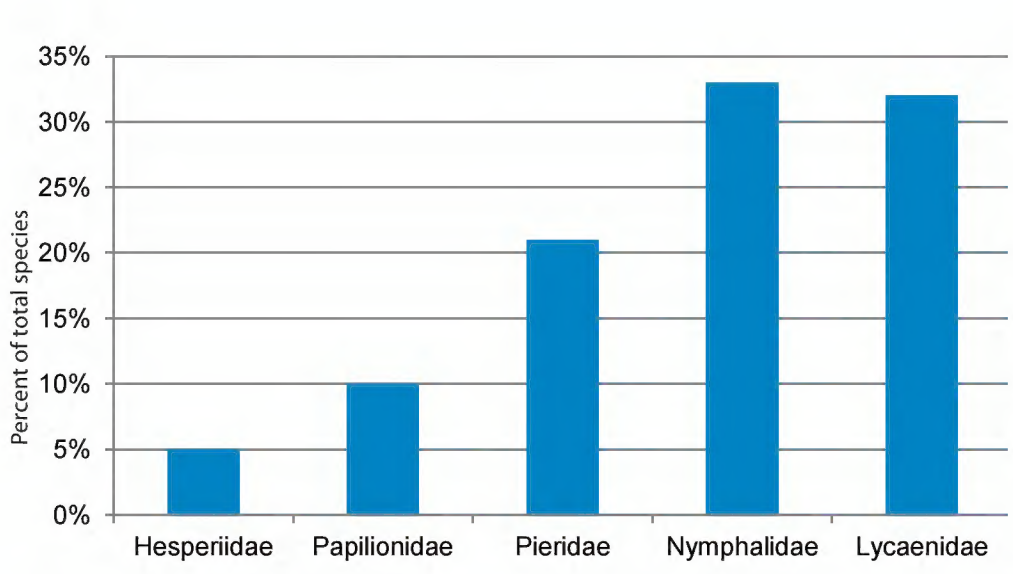


Figure 2. Species richness, by family, of butterflies in an arboretum, Vadodara, state of Gujarat, India (October 2012 to October 2013).

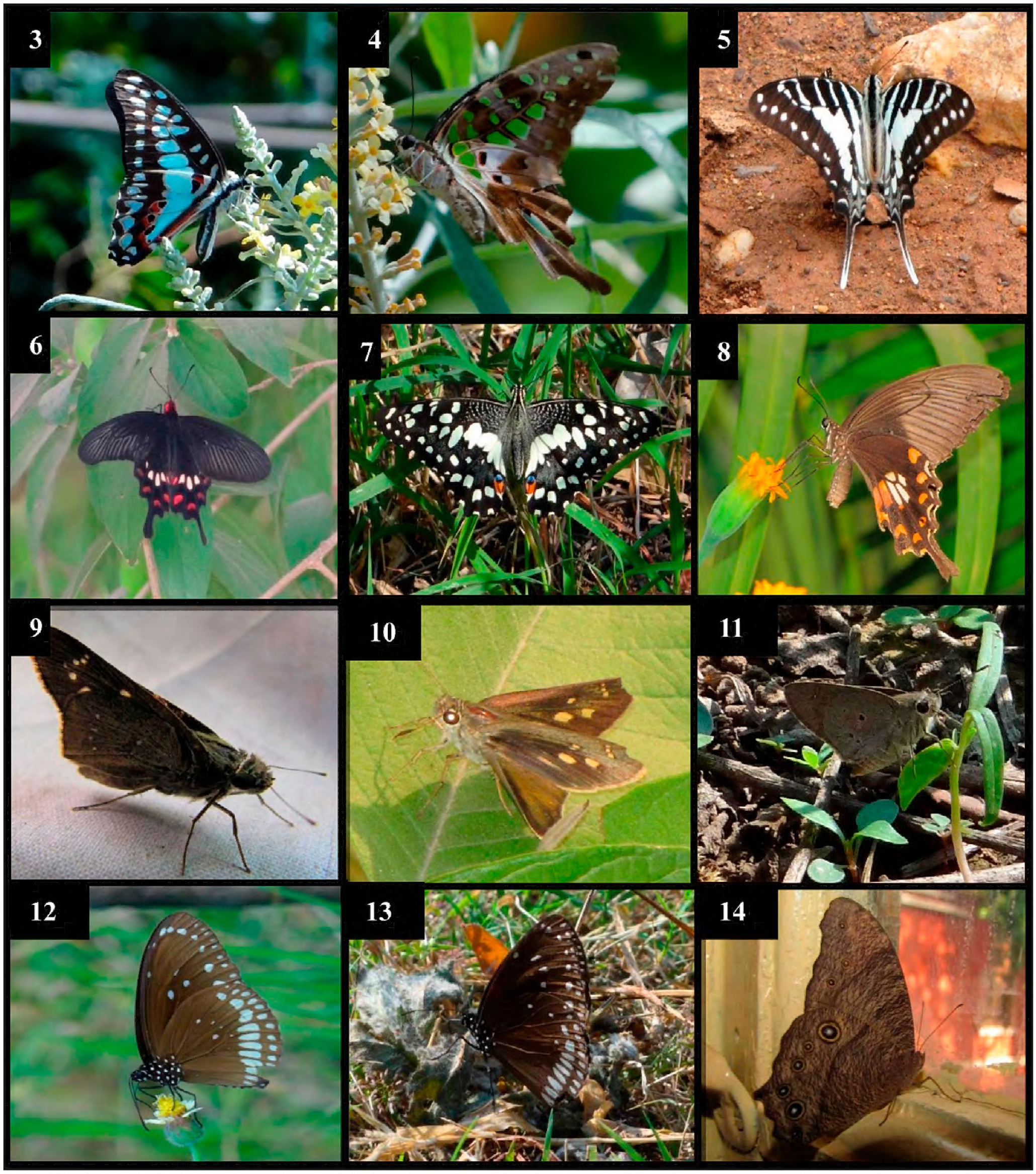
Family Papilionidae

Graphium doson (Felder & Felder, 1864) (Common Jay): Figure 3

Forewings black with a chain of little greenish spots on outer and inner edges. A chain of large greenish spots at the middle of the wing. Underside brown with pale color spots. Hindwings black with wavy edges. Chain of little greenish spots on outer edge. Next to the body, a large greenish coloration with a black strip. Underside similar to the upper side with additional red spots. Abdomen, thorax, and head black.

Graphium agamemnon (Linnaeus, 1758) (Tailed Jay): Figure 4

Forewings black with green spots. Nearby body the spots condensed to small green bands. Underside same as the upper side with brown ground. Hindwings black with short



Figures 3–14. Butterfly species recorded in an arboretum, Vadodara, state of Gujarat, India. **3.** *Graphium doson*. **4.** *Graphium agamemno*. **5.** *Graphium nomius*. **6.** *Pachliopta aristolochiae*. **7.** *Papilio demoleus*. **8.** *Papilio polytes*. **9.** *Borbo cinnara*. **10.** *Pelopidas mathias*. **11.** *Suastus gremius*. **12.** *Euploea core*. **13.** *Euploea klugii*. **14.** *Melanitis leda*.

tails. Two chains of green spots on wings. Two green stripes at the inner edge. Underside with brown base, similar to the upper side, but with darker green spots. Abdomen black with gray underside.

Graphium nomius (Esper, 1785) (Spot Swordtail): Figure 5

Forewings white with five black stripes. Outer edge of the wing black with a chain of white spots. Underside similar to the upper side with basic yellowish color with brown stripes at the outer edge. White hindwings with long tail and wavy edge. Middle of the wing with two black stripes. Black outer edge with a chain of white spots. Underside similar to upper side. A red band dominates the wing. Abdomen black with yellow underside. Thorax and head striped black and yellow.

Pachliopta aristolochiae (Fabricius, 1775) (Common Rose): Figure 6

Forewings black color had larger whitish part with black veins. Underside similar to the upper side. Black hindwings with tails. A white area in the middle of wing divided by black veins. Underside similar to upper side but with brighter red spots. Abdomen black. Male smaller than female. White area on wings absent and no red spots on upper side of hindwings.

Papilio demoleus (Linnaeus, 1758) (Lime Swallowtail): Figure 7

Forewings black with chain of yellow spots on outer edge. Next to body, four chains of irregular dull yellow spots. Underside similar to upper side with four yellow lines next to body. Black hindwings with wavy edge. Wing dominated by a broad, yellow band with big eye. Outer edge has five yellow spots whereas inner edge has a red eye-spot. Underside similar to the upper side but with larger yellow marks. Next to the body, a yellow area with black lines. Middle of the wing with blue and orange spots. Abdomen black with yellow underside.

Papilio polytes (Linnaeus, 1758) (Common Mormon): Figure 8

Forewings black with white spots at the margin. Underside similar to the upper side. Hindwings black with tails. A chain of white spots in the middle of wing. Underside similar to the upper side with a second chain of white spots. Abdomen black. Female with a broad whitish area, black veins or stripes on forewing. A white area with black veins in the middle of hind wings.

Family Hesperiidae

Borbo cinnara (Wallace, 1866) (Rice Swift): Figure 9

Forewing with basal half of its middle black, with small ochreous-white spots; three minute sub-apical spots in an outwardly oblique curve. Male upper side dark olive-brown. In some, no spots within the end of the cell, but in most, a minute dot at the upper end and in others two well-separated spots, one above the other. Hindwing produced at the anal angle, a discal series of minute white dots, varying in number in different examples. Underside paler and duller than upper side. Female same as male; the forewing not produced and comparatively broader; spots as on upper side, but larger; discal series of white dots on hindwing, sometimes complete on both sides.

Pelopidas mathias (Fabricius, 1798) (Small Branded Swift): Figure 10

Male upper side olive-brown. Forewing with two small yellowish semi-transparent spots within end of cell, three before apex; males with three oblique discal spots followed by a dark-bordered, slender, straight, impressed glandular streak. Hindwing with one or two very indistinct pale discal spots. Female with five discal spots in the forewing, and four or five in the hindwing. Underside paler; markings more distinct; hindwing also with a spot at upper end of the cell.

Suastus gremius (Fabricius, 1798) (Oriental Palm Bob): Figure 11

Underside of hindwing markings distinguish it from other skippers; underside of hindwing brown in both sexes, overlaid with gray scales, and bearing a variable number of black spots. Semi-transparent white spots on both sides of brown forewing.

Family Nymphalidae

Danaus chrysippus (Linnaeus, 1758) (Plain Tiger): Figure 55

Body black with white spots. Upper side of wings tawny, brighter and richer than underside. Upper side forewing tawny red, paler over the dorsal area. Costa and apex black, the latter crossed by a white, oblique bar with two white spots below its lower end. One or two white spots above and beyond apex of cell and a series of terminal white spots varying in size. Hindwing paler, termen narrowly black with a series of white spots. Underside similar but paler. Male smaller than female but more brightly colored.

Danaus genutia (Cramer, 1779) (Striped Tiger): Figure 56

Upper sides of forewings costal and dorsal margins and apical half of wing black. Three white spots above and beyond apex of cell followed by a pre-apical white band crossed by the veins; an incomplete subterminal and terminal series of white spots. Hindwing tawny red, veins and terminal margin black; the latter with two more or less complete rows of white spots. Underside of wings resemble upper side but paler. In drier regions, tawny part of the hindwing pale, almost white. Wings tawny, with veins marked with broad black bands, in box sexes.

Tirumala limniace (Cramer, 1775) (Blue Tiger): Figure 57

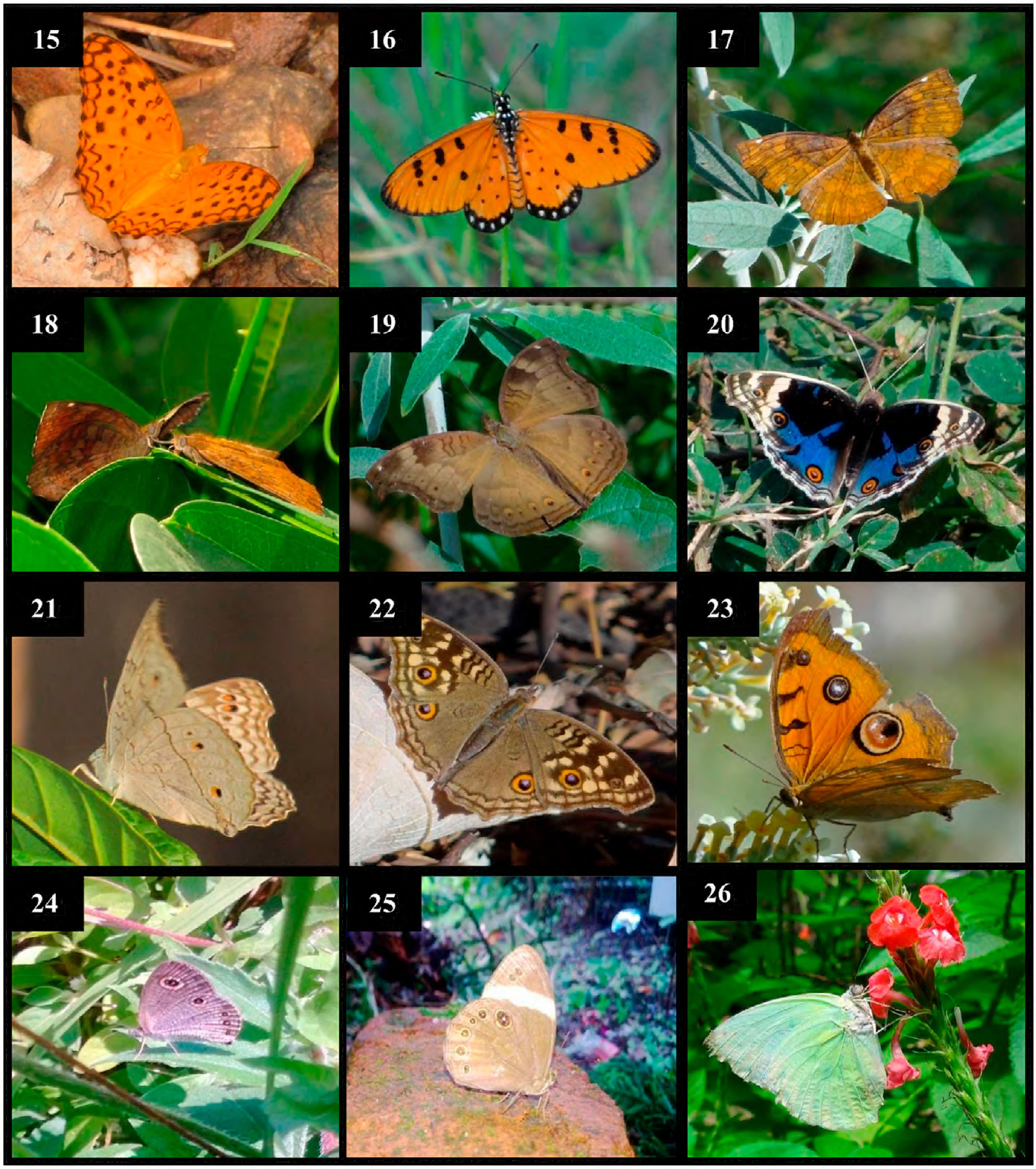
Upperside black, with bluish-white semihyaline spots and streaks. Underside basal two-thirds of forewing dusky black, apex and hindwing olive-brown; spots and streaks much as on upper side. Antennae, head, and thorax black, the latter two spotted and streaked with white. Abdomen dusky above, ochraceous, and spotted with white beneath.

Parantica aglea (Stoll, 1782) (Glassy Tiger): Figure 58

Ground-color fuliginous black with subhyaline bluish white streaks and spots. Antennae black; head and thorax black spotted with white. Abdomen blackish brown, ochraceous beneath.

Euploea core (Cramer, 1780) (Common Crow): Figure 12

Glossy black with brown underside and white markings



Figures 15–26. Butterfly species recorded in an arboretum, Vadodara, state of Gujarat, India. **15.** *Phalanta phalantha*. **16.** *Acraea terpsicore*. **17.** *Ariadne merione*. **18.** *Ariadne ariadne*. **19.** *Junonia iphita*. **20.** *Junonia orithya*. **21.** *Junonia atlites*. **22.** *Junonia lemonias*. **23.** *Junonia almanac*. **24.** *Ypthima huebneri*. **25.** *Lethe verma*. **26** *Catopsilia pomona*.

along the outer margins of both wings. Male with a velvety black band located near rear edge on upper side of fore-wing. Underside with a white streak in same location in both males and females. Upper side dark brown, broadly paler along terminal margins; forewing and hindwing with subterminal and terminal series of white spots; on forewing the former more or less oval; hind wing with a submarginal row of white spots . Underside similar, but ground-color more uniform.

Euploea klugii (Moore, 1857) (King Crow): Figure 13
Upper side: forewing dark-brown glossed with brilliant blue, generally a spot at apex of cell, a small costal spot, two short streaks beyond apex of cell, subterminal and

terminal series of spots, (in the female the latter series wanting) all bluish-white in colour. Hindwing brown, glossed with blue in the middle, sub-terminal series of spots incomplete or absent. Underside: not glossed with blue, spots more complete and clearly defined. Head and thorax spotted with bluish-white.

Melanitis leda (Linnaeus, 1758) (Common Evening Brown): Figure 14

Wet-season form: Forewing apex subacute; termen slightly angulated just below apex, or straight. Upper side brown. Forewing with two large subapical black spots, each with a smaller spot outwardly of pure white inwardly bordered by a ferruginous interrupted lunule; costal margin narrowly pale. Underside paler, densely covered with transverse dark brown striae; a discal curved dark brown narrow band on forewing.

Dry-season form: Forewing apex obtuse and more or less falcate. Upper side with ground-color similar to wet-season form, the markings, especially ferruginous lunules inwardly bordering the black subapical spots on forewing, larger, more extended below and above black costa. Antennae, head, thorax, and abdomen in both forms brown or grayish brown.

Phalanta phalantha (Drury, 1773) (Common Leopard): Figure 15

Upper side tawny with rows of small black spots and wavy lines. Upper forewings with a fair number of black spots and streaks. Underside pale brownish with indistinct markings and glossier than the upper side. During dry season, underside with more prominent purple gloss.

Acraea terpsicore (Linnaeus, 1758) (Tawny Coster): Figure 16

Upper side: forewing with a transverse black spot in cell, and another irregular, oblique and broader at the discocellulars. Upper four spots of discal series inclined obliquely outwards, lower two obliquely inwards; black edging to apex and termen narrowing posteriorly.

Underside: ground-color ochraceous yellow or a paler tawny yellow. Forewing paling to whitish on the apex, with the black markings as on the upper side blurred and diffuse. Hindwing with black spots and black terminal band as on the upper side, but the spots more clearly defined, none obscure; the base of the wing black, separated from the basal transverse series of black spots by two or three large whitish spots. Antennae and abdomen black.

Ariadne merione (Cramer, 1777) (Common Castor): Figure 17

Upper side of both wings rusty brown. Upper forewing apex square cut. Underside grayish brown with dark brown narrow bands. Male with a triangular black patch of scent scales at base-cell on under forewing. Female with distinct bands between wavy lines, especially in dry season form.

Ariadne ariadne (Linnaeus, 1763) (Angled Castor): Figure 18

Similar to *Ariadne merione*, but darker with black lines regular, slender and well-separated. Underside darker brown with purplish brown markings. Seasonal variations apparent.

Junonia iphita (Cramer, 1779) (Chocolate Pansy): Figure 19

Upper side pale to dark brown with darker brown bands. Upper hindwing with a row of small eyespots. Upper forewing with or without small eyespots. Forewing apex and hindwing tornus slightly produced. Forewing apex square-cut and termen concave. Underside leaf-like.

Junonia orithya (Linnaeus, 1758) (Blue Pansy): Figure 20

Blue upper hindwing with velvety black inner area. Basal two-thirds of upper forewing black, apex pale brown with white bands, outer discal area bellow apex shining blue. Variegated eyespots on both wings. Female larger, upper hindwing with eyespots more prominent, and more extensively black basal area than in male.

Junonia atlites (Linnaeus, 1763) (Gray Pansy): Figure 21

Upper side creamy gray with dark brown lines and with complete row of discal eyespots on both wings.

Junonia lemonias (Linnaeus, 1758) (Lemon Pansy): Figure 22

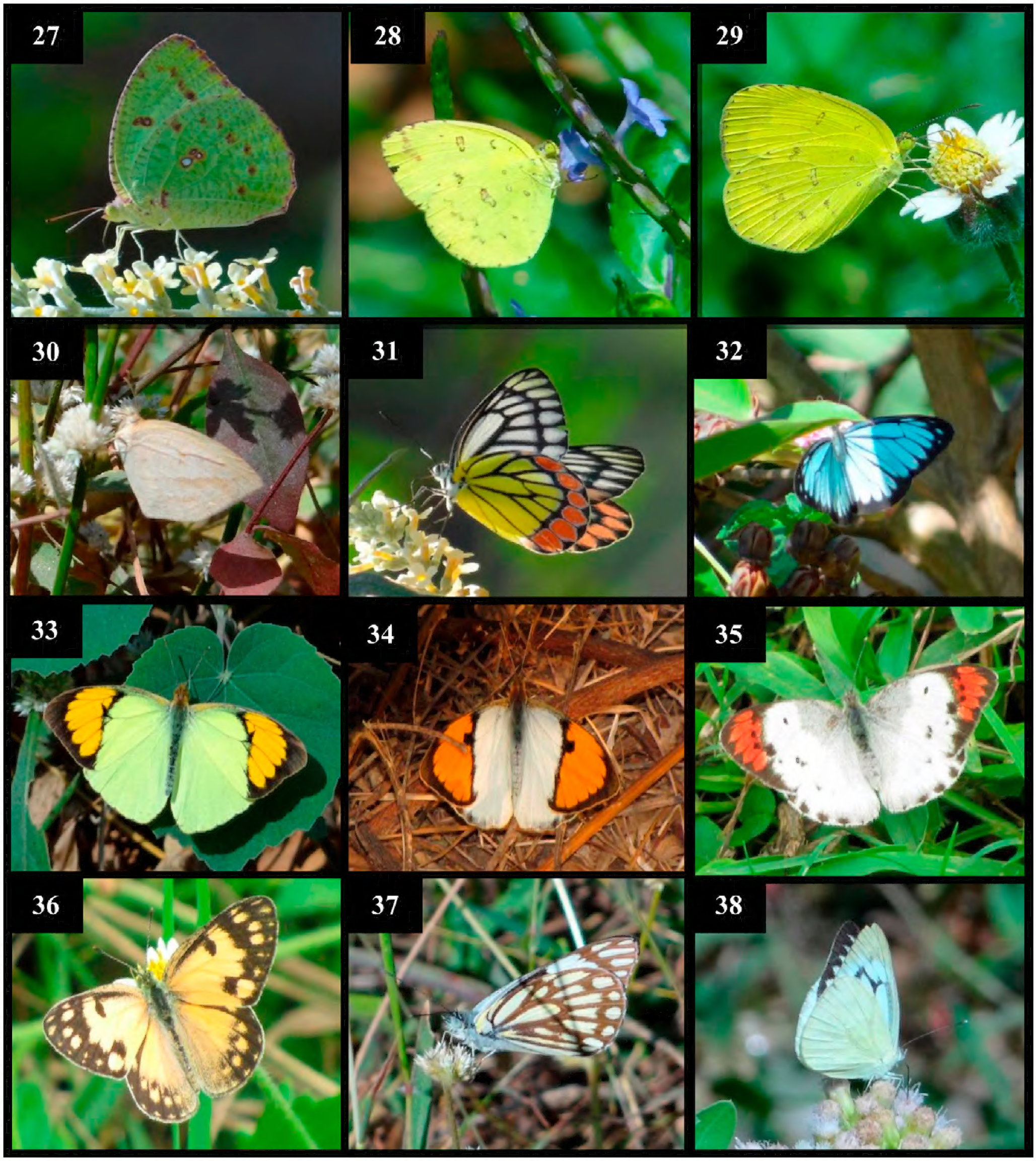
Forewings brown with several eyespots, and black and lemon yellow spots on upper side. Upper forewing with lemon-yellow spots.

Junonia almana (Linnaeus, 1758) (Peacock Pansy): Figure 23

Upper side tawny orange with prominent eyespots on both wings; large unmistakable eyespot on upper hindwing and two smaller eyespots on upper forewing. Upper forewing apex square-cut not pointed, and termen concave. Three narrow black lines along border on upper side of both wings.

Hypolimnas misippus (Linnaeus, 1764) (Danaid Eggfly): Figure 59

Male upper side black with white oval or egg-shaped discal patches on both wings. Small oval spot on upper forewing apex. Underside male rusty brown with a narrow white band on under forewing and a broad white band on under hindwing. Females mimics *Danaus chrysippus* and differ by wavy hindwing margin. Upper side tawny with upper forewing apex. Upper hindwing with prominent black costal spot, and black border with a series of white spots. Underside paler.



Figures 27–38. Butterfly species recorded in an arboretum, Vadodara, state of Gujarat, India. **27.** *Catopsilia pyranthe*. **28.** *Eurema hecabe*. **29.** *Eurema brigitta*. **30.** *Eurema laeta*. **31.** *Delias eucharis*. **32.** *Pareronia hippia*. **33.** *Ixias pyrene*. **34.** *Ixias marianne*. **35.** *Colotis danae*. **36.** *Colotis amata*. **37.** *Belenois aurota*. **38.** *Cepora nerissa*.

Hypolimnas bolina (Linnaeus, 1758) (Great Eggfly): Figure 60

Male on upper side was black with a white centered, iridescent blue, oval spot on each wing. Spot larger on upper hindwing. On upper side, a row of big white spots along margin from apex to tornus. Females mimics *Euploea core*, but wings broader, forewing termen concave, and hindwing with scalloped border. Female upper side dark brown with outer discal row of small white spots on both wings. Hindwing termen with a dark wavy line.

Ypthima huebneri (Kirby, 1871) (Common Four-ring): Figure 24

Wet-season form: Upper side pale-brown. Fore wing with

the usual pre-apical ocellus; hindwing with two, sometimes three and rarely without any ocelli. Underside greyish, not densely covered with transverse brown streaks. Forewing with the pre-apical ocellus as on the upper side, hindwing with one apical and three contiguous posterior ocelli. Both wings crossed by dark bands, faint on the hind wing. Antenna, head, thorax and abdomen greyish brown, the abdomen paler beneath.

Dry-season form: Both the upper and undersides paler, the dark bands across the wings more pronounced and the ocelli on the underside of the hindwing minute or absent.

Lethe verma (Kollar, 1844) (Straight-banded Treebrown): Figure 25

Upper side: brown. Forewing with an even oblique white discal band ending on the termen just above vein 2 in the males but continued below that vein in the females. Hindwing with two or three faint white-centred black oceli and both wings with pale sub-terminal and terminal lines. Underside: forewing with the white oblique band as on upper side, two sub-apical white-centred yellow-ringed black ocelli. Hindwing with two irregular lilac transverse lines and a post-discal series of white-centred black ocelli encircled with a yellowish, a brown and a silvery ring. Two pale terminal lines as usual.

Family Pieridae

Catopsilia pomona (Fabricius, 1775) (Lemon Emigrant): Figure 26

Both sexes yellow to translucent greenish white with black or red antennae. Markings highly variable. Underside unmarked, or with red-ringed silver spots in center; additional markings on both wings. Upper forewing termen, apex, and costa with variable narrow to broad black margin.

Catopsilia pyranthe (Linnaeus, 1758) (Mottled Emigrant): Figure 27

Both sexes chalky white to greenish yellow with variable markings. Underside closely mottled with fine brown or green lines. Under hindwing with or without distinct red-ringed silver spots in center. Male upper forewing with or without cell spot; apical and outer margin with variable black boarder. Upper hindwing unmarked or have continuous terminal markings. Female similar to male, but black markings broader and cell spot larger on upper forewing.

Eurema hecabe (Linnaeus, 1758) (Common Grass Yellow): Figure 28

Wet-season form: Male bright yellow, upper forewing apex, and termen broadly black. Upper hindwing with narrow black terminal border. Female similar with broader black borders. In both sexes, under forewing with two black spots in cell; one or both spots may be absent.

Dry-season form: Narrower border on upper forewing and rusty markings on underside of both wings. Male with fairly prominent band near base of under forewing.

Eurema brigitta (Stoll, 1780) (Small Grass Yellow): Figure 29

Both sexes bright yellow with upper forewing outer margin and apex broadly black with inner edge of border evenly curved along costa. Outer margin of upper hindwing broadly or narrowly black. Two small black spots at end-cell on under forewing. Female with broader marginal borders. Male with no band.

Eurema laeta (Boisduval, 1836) (Spotless Grass Yellow): Figure 30

Wet-season form: upper forewing apex and termen broadly black, the inner edge being unevenly rounded and scalloped. Upper hindwing with narrow terminal black border. Under forewing with a small black spot at end-cell. Female with broad borders and denser black dusting on underside. Dry season form: forewing apex pointed and outer margin sharply cut and straight. Upper forewing with black apex, upper hindwing dark margin reduced or absent. Under hindwing pale yellow densely shaded with brown and pink scales and two straight darker brown streaks. Male with band on hindwing near base on both sides.

Delias eucharis (Drury, 1773) (Indian Jezebel): Figure 31

Under hindwing yellow, veins black; prominent row of marginal red spots. Above white, veins black on forewing in males, on forewing and hindwing in females. Under hindwing with red marginal spots, black bordered and a corresponding black post on discal line of upper hindwing.

Pareronia hippia (Fabricius, 1787) (Indian Wanderer): Figure 32

Male pale blue or bluish white on upper side, with black margin not broad, bearing, on upper forewing, prominent marginal spots that increase in size towards apex. Underside less bluish in both sexes.

Ixias pyrene (Linnaeus, 1764) (Yellow Orange-tip): Figure 33

Male upper side yellow. Upper forewing with black apical half, enclosing a large orange band. Upper hindwing with black border. Underside yellow with brown blotches in both sexes. Female with white or yellow coloration on upper side. White female with white apical band and yellow female with apical band reduced in size with two black spots.

Ixias marianne (Cramer, 1779) (White Orange-tip): Figure 34

Both sexes white. Apical half of upper forewing black, enclosing a large orange patch. Upper hindwing with black terminal border. Orange patch on female upper forewing narrow, with four black spots. Area near base and cell dusted

Figures 39–50. Butterfly species recorded in an arboretum, Vadodara, state of Gujarat, India. **39.** *Curetis thetis*. **40.** *Rapala iarbus*. **41.** *Tarucus nara*. **42.** *Euchrysops cnejus*. **43.** *Catochrysops strabo*. **44.** *Zizeeria karsandra*. **45.** *Zizina otis*. **46.** *Zizula hylax*. **47.** *Lampides boeticus*. **48.** *Chilades parrhasius*. **49.** *Chilades pandava*. **50.** *Chilades lajus*.

with black. Markings on both sexes during dry season form more pronounced on underside, but wet season form more heavily marked on upper side.

Colotis danae **(**Fabricius, 1775) (Crimson-tip): Figure 35

Male upper side white, base of wings generally irrorated to a varying extent with black scales. Upper side forewing with or without a minute black spot on the disco-cellulars. Upper side hindwing uniform, except for a series of black terminal spots. Underside white. Underside forewing with base of cell washed with sulphur-yellow; spot on disco-cellulars as on the upper side. Underside hindwing light ground-color, often heavily, suffused with ochraceous pink. Female upper

black band of specialized scales on costal margin.

Belenois aurota (Fabricius, 1793) (Pioneer): Figure 37

Both sexes with white upper side and a characteristic hockey-stick-shaped black disco-cellular bar on both sides of forewing. Male upper forewing with white-streaked black apex. Upper hindwing with white-spotted black border.

Cepora nerissa (Fabricius, 1775) (Common Gull): Figure 38

Wet-season form: Male upper side with white with gray scaling at the base and some veins were black. Upper forewing with black terminal outer border, broader at apex and often bearing white spots. Upper hindwing with black triangular marginal spots. Under forewing with white with yellow apex and costa with black or dark yellow under hindwing. Underside veins heavily outlined in dark scaling. Female upper side with black markings and dark veins. Upper forewing with stripes and spots of white ground color. Upper hindwing with a submarginal series of grayish white double spots and a broad white cell stripes. Underside similar to male.

Dry-season form: Black marking reduced in both sexes, and under hindwing may be yellow to pale brown, almost unmarked.

Family: Lycaenidae

Curetis thetis (Drury, 1773) (Indian Sunbeam): Figure 39

Hindwing tailless. Both sexes glossy white on underside and with no small black dots other than those marking up the lines or bands. Male dark cupreous red, glossy and shining on upperside and in dry season form with narrow black borders, thread-like on upper hindwing. In wet season form, borders are broader. Black border on upper forewing not continued along termen. Forewing base irrorated with dusky scales. Hindwing base and dorsum broadly but slightly irrorated with dusky scales. Female has broad border on upper side, with narrow white discal area; while discal areas broad in dry season form, and reduced in wet season form. Hindwing termen evenly rounded.

Virachola isocrates (Fabricius, 1793) (Common Guava Blue): Figure 61

Hindwing with one slender tail. Both sexes with pale gray-brown on underside, with markings slightly darker. White-bordered discal band straight on under forewing. Male upper side dull brown, shot with purple scales. Upper forewing costa and margin black. Entire upper hindwing overlaid with shining purple. Male with a tuft of dark brown scent scales on mid-dorsum on under forewing. Female upper side fuscous brown without purple, but with dull orange patches at end-cell on upper forewing and a prominent black-centered orange tornal spot on upper hindwing. Female larger than male.

Rapala iarbus (Fabricius, 1787) (Common Red Flash): Figure 40

Hindwing has one tail and a lobe. Underside slaty gray, no ochreous tinge. Male upper side red to orange with dark brown costal and distal border on the forewing. Female upper side dull, coppery and with broad, dark brown borders. Underneath, both sexes with pale grayish buff.

Castalius rosimon (Fabricius, 1775) (Common Pierrot): Figure 62

Hindwing with white-tipped black tails. Underside conspicuously marked with black spots and streaks on white. Square black spots more on under forewing. Under hindwing with a metallic green spot at tornus. Upper side white with dark borders and black spots; basal area powered with metallic blue scales. Female had basal area suffused with dark scales; otherwise sexes alike. Wet season form heavily marked.

Tarucus nara (Kollar, 1848) (Striped Pierrot): Figure 41

Hindwing tailed. Underside white with prominent black streak in under forewing cell, and black marks elongated into streaks rather than rounded spots. Male dull violet-blue on upper side, with a cell spot but no other discal spots on upper forewing. Female dull brown on upper side. Markings variable, especially in wet season form.

Euchrysops cnejus (Fabricius, 1798) (Gram Blue): Figure 42

Hindwing tailed. Two prominent orange-crowned, black tornal spots with metallic silver centerson under hindwing, one on either side of tail. Male pale violet-blue on upper side. Female brown on upper side, with sparse blue scaling at base of both wings. Underside in both sexes light gray, marked with thin lines and spots.

Catochrysops strabo (Fabricius, 1793) (Forget-me-not): Figure 43

Hindwing tailed; comparatively larger and more elegant than *Euchrysops cnejus*. Wings narrow. Underside pale gray with white-edged fawn discal bars. Male shining violet-blue on the upper side. Female pale earthy brown, with a flush of faint silvery blue. Both sexes with a small black spot on the upper hindwing next to the tail; and in female, hindwing was marked inwardly with an orange crescent.

Zizeeria karsandra (Moore, 1865) (Dark Grass Blue): Figure 44

Hindwing tailless, much smaller than *Pseudozizeeria maha*. Underside grayish brown with small, distinct rounded black spots. Male upper side dark blue, with dark brown broad border along costa and termen of upper forewing, and broad border on costa, narrow along termen of upper hindwing. Female upper side dark brown with blue scales at wing bases.

Zizina otis (Fabricius, 1787) (Lesser Grass Blue): Figure 45

Figures 51–62. Butterfly species recorded in an arboretum, Vadodara, state of Gujarat, India. **51.** *Freyeria putli*. **52.** *Anthene lycaenina*. **53.** *Prosotas dubiosa*. **54.** *Leptotes plinius*. **55.** *Danaus chrysippus*. **56.** *Danaus genutia*. **57.** *Tirumala limniace*. **58.** *Parantica aglea*. **59.** *Hypolimnas misippus*. **60.** *Hypolimnas bolina*. **61.** *Virachola isocrates*. **62.** *Castalius rosimon*.

side white; base of wings light, often heavily, irrorated with grayish-black scales. Underside forewing white, suffused with sulphur-yellow at base of cell.

A white butterfly with crimson tips to the forewings. In flight, male appears brighter than the female due to smaller black markings and the larger, more intense crimson patch.

Colotis amata (Fabricius, 1775) (Small Salmon Arab): Figure 36

Salmon-pink upper side in both sexes. Upper forewing with black costal border touching black spot at end-cell; apical half bearing spots of ground color. Similar spotting on dark outer border on upper hindwing. Male upper hindwing with

Hindwind tailless. Underside pale grayish brown with rounded, not very dark spots. Under forewing without costal spots or any spot inside the cell. Male upper side dark blue with fairly distinct black border along termen, broadening towards apex. Female upper side dark brown, with iridescent blue scaling at wing bases.

Zizula hylax (Fabricius, 1775) (Tiny Grass Blue): Figure 46

Hindwind tailless. Underside pale grayish brown with fine, small, distinct, dark brown or black spots. Underside forewing with row of discal spots. Under hindwing with two small costal spots and a spot near the end cell bar; also with a spot in the cell next to two more spots near base. Male upper side pale blue,upper side with narrow black border on upper hindwing, and broad, diffused black border covering most of upper forewing apex. Female upper side brown, without blue scaling.

Lampides boeticus (Linnaeus, 1767) (Pea Blue): Figure 47

Hindwing tailed. Underside pale brown with darker brown bands rimmed with white on both wings. No spots on under forewing. distinct larger band within outer margin on under hindwing, where the dark brown bands are absent. Two orange-ringed black tornal spots, often with metallic silver crown on under hindwing. Male upper side pale blue, with narrow dark borders and two black tornal spots on upper hindwing. Female upper side dark earthy brown, with a slight flush of pale blue scales at bases of wings.

Chilades parrhasius (Fabricius, 1793) (Small Cupid): Figure 48

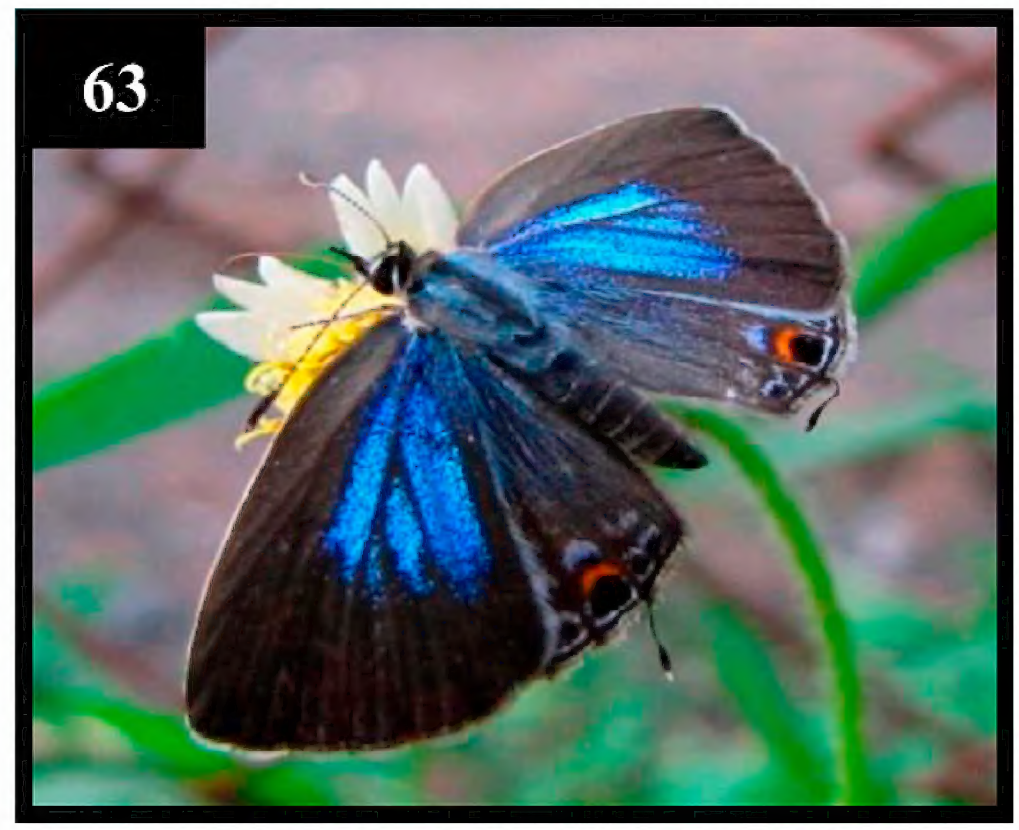
Hidwind tailed. Underside white, with some black spots, but others gray and hardly darker than background. Male upper sede dark blue, with broad border on upper forewing, and two black tornal spots, more conspicuous than rest of border on upper hindwing. Female brown or black with or without pale blue discal areas, except for black-spotted orange tornal patch on upper hindwing.

Chilades pandava (Horsfield, 1829) (Plains Cupid): Figure 49

Hindwing has white-tipper tail. Both sexes have marginal and discal rows of linked spots, slightly darker than brownish gray background on underside. Similar to *Chilades parrhasius*, but has four spots near underside hindwing base, while *Chilades parrhasius* has three spots. Male upper side blue with thin black borders on both wings and a black tornal spot on hindwing. Female paler blue with broad borders on the forewing and with a series of submarginal spots on the hindwing.

Chilades lajus (Stoll, 1780) (Lime Blue): Figure 50

Hindwing tailless. Underside light with several dark spots. Among these spots, one pair of spots on each wing, joined at right angles. Male upper side dull purplish blue with thin



Figures 63. Butterfly species recorded in an arboretum, Vadodara, state of Gujarat, India. *Jamides bochus*.

black border, while female blackish brown with metallic blue wing bases. Markings in dry season form vary, underside more brown than gray, with dark brown patch near terman of under hindwing.

Jamides bochus (Stoll, 1782) (Dark Cerulean): Figure 63

Hindwing tailed in female, but male not always tailed. Underside darkish brown, speckled and marked with an orange crowned black spot at the tornal area of the hindwing. Male upper side dark iridescent blue, with basal areas pale milky blue and broad black border on forewing extending into cell. Female dull blue with similar broad black borders, and on upper hindwing, dark marginal spots crowned with white lunules.

Freyeria putli **(**Kollar, 1844) (Oriental Grass Jewel): 51

Hindwing tailless. Underside gray to light brown. Two black spots along costa on under hindwing; other spots dark brown. Black spots crowned with metallic green and orange at under hindwing margin. Both sexes dark brown on upper side, with three or four orange-crowned black spots along upper hindwing termen.

Anthene lycaenina (Felder, 1868) (Pointed Ciliate Blue): Figure 52

Hindwing tailless, but with three very short, small tufts formed by slight elingations of the fringe. Male upper side purple-blue. Female upper side brown with blue base and dark marginal spots on upper hindwing.

Prosotas **dubiosa** (Semper, 1879) (Tailless Lineblue): Figure 53

Hindwing tailless. Smaller in size than *Prosotas nora* and underside pale brown with pairs of white-margined darker bands. Male upper side dull purple blue, with thin black

line borders, and with indistinct small tornal black spot on upper hindwing. Female upper side blackish brown, with iridescent pale blue panels on upper forewing.

Leptotes plinius (Fabricius, 1793) (Zebra Blue): Figure 54

Hindwing tailed. Typical zebra-like markings on underside unmistakable, but similar to *Castalius rosimon*. Male upper side of the wing violet-blue and forewing with brownish black markings. Hindwing with costal margin slightly but broadly shaded with fuscous, which is continued as a slender anticiliary black line to the tornus. Female upper side brown, basally blue, with dark-spotted white discal areas.

DISCUSSION

Butterfly diversity is largely dependent on a rich flora, because larval host-plant relationships are frequently so specific (Murphy & Wilcox 1986). Therefore, the conservation of butterfly diversity is achievable by the enhancement of vegetation in habitats specifically preferred by butterflies (Lawton et al. 1998). Some butterflies are ecological indicator species and play a vital role by cross-pollination of plants (Bonebrake et al. 2010). We found our study area to have a rich diversity of butterfly species, which include nine rare and threatened species listed under schedule I of part IV of the Indian Wildlife Protection Act, 1972. As butterflies are highly sensitive to human-induced changes to the environment, an assessment of their response to these changes is needed to identify the indicator species (Kremen 1992; Barlow et al. 2007). The baseline data that we present here can serve as a reference for similar future studies. Research on interactions of butterfly species with specific host plants, distribution of butterfly species, and priority areas for butterfly conservation will all be helpful to better understand the conservation needs of these creatures and the ecosystem as a whole.

ACKNOWLEDGEMENTS

We thank Prof. Arun Arya and Dr. Dolly Kumar for helping with fieldwork and providing necessary guidance throughout our research. Thanks are also due to Mr. Amit Kumar, Dr. Vineet Dubey, Ms. Aashna Sharma and Mr. Vivek Sarkar for necessary inputs and suggestions.

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AuthorS' contributions: UB collected, identified and photographed the specimens, as well as wrote the manuscript; PN guided the fieldwork and helped with identifications.

Received: 8 October 2015
Accepted: 10 October 2016
Academic editor: Ricardo R. Siewert